METHOD AND APPARATUS FOR LASER INSCRIPTION OF AN IMAGE ON A SURFACE

Field of the Invention

The invention relates to the inscription of images on a surface and more particularly to a method and apparatus for creating permanent images on glass and other inorganic oxide containing surfaces using high energy light.

Background of the Invention

The inscription of images on various surfaces has become increasingly important in recent years for the permanent identification of valuable objects in addition to forming decorative designs on surfaces. For example, for the permanent identification of automobiles, trucks and the like, vehicle VIN Numbers or other identifying indicia are permanently inscribed on the windows of the vehicle at various locations to provide a non-removable identification for the vehicle. Many insurance companies offer a discount from the cost of insuring the vehicle if such permanent indicia are placed on the vehicle. Such indicia, for example a bar code, can also provide an access code for the retrieval of the history of the vehicle, such as for example its previous owner, its maintenance history and the like.

Conventionally, the inscription process is accomplished by mechanical or chemical means. For example, a malleable surface, such as wood, certain precious metals and the like, can be mechanically inscribed using a router or similar tool. These tools can be manually operated by persons possessing relatively high degree of skill or can be robotically controlled to mass produce inscriptions of various kinds on the malleable surface. However, manual operation is slow and not suited to repetitive operations while robotic equipment is expensive and can present a substantial

maintenance problem.

In the case of hard surfaces such as glass, chemical etching utilizing a stencil is a common method employed for the inscription of indicia on the surface of the glass. A suitable etchant is placed on the back of the stencil and the etchant contacts the glass surface through the openings in the stencil. The etchant chemically attacks the surface to permanently etch an image corresponding to the stencil openings into the glass surface. Examples of such methods are represented by U. S.Patent 4,585,514 granted April 29, 1986 to L. Joe Scallan and U. S. Patent 4,985,115 granted January 15, 1991 to Thomas DeRossett. Both of these employ chemical etchants to etch an image into the surface of glass.

It is well understood, however, that glass and other inorganic oxide containing materials are relatively chemically resistant. Therefore, the etchant must be of a highly corrosive nature in order to react with the glass surface to form an image. Most of the etchant compounds are hydrogen fluoride based and as such, are highly corrosive and dangerous to use. Also, disposal of such materials can also be a serious problem in view of the potentially harmful environmental affect such materials may have. These materials must be treated as toxic substances and disposed of only at approved sites and transported in an approved manner. Needless to say the disposal of toxic materials is an expensive operation.

As an alternative to the chemical etch, sandblasting can be utilized as a method for etching glass and other similar surfaces. Sandblasting, if not properly carried out, also posses an environmental threat as well as a potential safety hazard to the operators and other personnel in the immediate area of the sandblasting operation. It is necessary to provide adequate protection for the operators of the sandblasting equipment as well as expensive air filtering apparatus to avoid air pollution violations.

Neither chemical etching nor sandblasting readily lend themselves to automation and in most cases, the indicia which can be etched onto the glass surface are limited to non-machine readable numbers. Moreover, poor technique, particularly in the case of chemical etching, can lead to

erroneous results due to blurring of the etched image making it difficult to read, especially by machine. It must be noted, particularly in the case of automobile VIN numbers, that accuracy and image quality are of the utmost importance and mistakes require the replacement of the vehicle window or windshield, an expensive procedure.

Accordingly, laser etching or inscription of indicia has become a method of choice, particularly for the permenent inscription of indicia such vehicle VIN numbers. U.S. Patent 5,298,717, issued March 29, 1994 in the name of Thomas Derossett is an example of a laser etching system and apparatus for the permanent inscription of vehicle VIN numbers on areas of the vehicle glass, such as a lower non-interfering portion of the windshield or side windows. Derossett describes apparatus utilized to carry out the laser inscription of a surface, including auto safety glass that includes an emitter housing in which the laser emission source is located. The emitter housing further includes control means for controlling the output beam to form the desired pattern. A marking head separate from the emitter housing electronically and optically communicates with the emitter housing. Beam directing means in the marking head are electronically connected to the control means in the emitter housing to direct the beam from the emission end of the marking head over the surface to etch the desired pattern. The marking head optically communicates with the emitter housing by a flexible arm defining an enclosed optical path from the emitter housing for conducting the emission beam to the marker head. While the Derossett apparatus is successfully used to inscribe VIN numbers the apparatus requires frequent time consuming adjustments to the optical path in order to insure correct alignment of the laser beam. In addition, replacement of marking heads can be time consuming due to the necessity of assembling the new marking head and the flexible optical path and aligning the laser beam with the optical path and the marking head.

Summary of the Invention

As used herein, the terms etch and etching are defined as any process for the permanent inscription of an image into a surface be it a chemical or physical process, including the use of high

energy light.

It is an object of the present invention to provide an improved apparatus for the laser inscription of indicia onto a surface.

Another object of the present invention is to provide apparatus for etching surfaces which can be operated by a minimum of personnel in a safe and efficient manner.

Still another object of the invention is to shorten the light path from the laser to the surface being etched.

Yet another object of the invention is to provide apparatus for laser inscription of a surface that requires less maintenance.

These and other objects and features of the present invention are achieved by the present invention by which an image is inscribed into surface employing a laser generated high intensity beam. An emitter includes a laser that, in response to a firing signal initiated by the operator, emits a high intensity beam of light that is communicated to marking head that is pivotally mounted on the housing in which the laser source is located. The beam is controllably directed by the marking head onto the surface being etched to scribe an image representing the input data into the surface.

In one embodiment of the invention the surface being etched in accordance with the invention comprises glass or other inorganic oxide containing materials which may be transparent to the laser output. Accordingly, a laser having an emission to which glass is not transparent must be used. For example, eximer and CO2 type lasers provide an emission beam which is highly effective for etching glass. In addition to the CO2 and eximer laser, other laser emission sources, such as the YAG laser, are suited for use in this invention where the material being etched is not transparent to the emission beam. Such materials include wood, plastics and metal alloys. It will be understood, therefore, that the selection of laser emission source is a matter of choice depending upon the surface being etched as is well understood in the art.

The apparatus utilized to carry out the foregoing method includes an emitter housing in which

the laser emission source is located. A marking head is pivotally affixed to the emitter housing and electronically and optically communicates therewith. Beam directing apparatus in the marking head is electronically connected to a controller to receive and process the signals for controlling the beam directing apparatus to move the laser beam over the surface to etch the desired pattern. Preferably, the marking head is provided with one or more suction devices for securing the marking head in proper alignment and spacing with the surface being etched and interlocks are provided to prevent the firing of the laser until the marking head is correctly positioned with respect to the surface to be etched.

In a preferred embodiment means are provided to draw a vacuum at the marker head during the etching process as an aid in securing the marker head against the surface being etched.

While the emitter housing and marking head are separate units, the marking head is located immediately adjacent to the laser source to shorten the optical path for the laser beam. The marking head is pivotally carried by the emitter housing for pivoting movement in relation to the emitter housing. The marking head may be mounted on either sidewall or the top or bottom wall of the emitter housing.

A controller electronically communicates with the marking head and is programmed, such as by suitable software, for issuing control signals representing the x and y coordinates of the emission beam to the marking head. Responsive to the coordinates, the emission beam is directed over the target area to form the desired pattern. A preferred means for directing the emission beam comprises motor driven mirrors in the marker head which are placed in the path of the emission beam. The mirrors are driven by their respective motors to rotate responsive to the coordinates provided by the control signals to reflect the emission beam in the desired x and y direction over the surface being etched to form the desired image.

Other objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the drawings.

Brief Description of the Drawings

FIG. 1 is a simplified view of the apparatus in accordance with the present invention;

FIG. 2 is a top plan view of the apparatus of FIG. 1;

FIG. 3 is a perspective view of the emitter housing illustrating the mounting face;

FIG. 4 is view of the side wall of the marking head, broken away for purposes of illustration, showing a cylindrical extension that is journaled in the mounting face of the emitter housing of FIG. 3;

FIG. 5 is a side sectional elevation of the marking head of FIG. 1;

FIG. 6 is a top sectional view in enlarged scale of the emitter housing partially broken for compactness of illustration showing the alignment mirror for directing the laser beam into the marking head; and

FIG. 7 is a schematic diagram of the system.

Detailed Description of the Invention

The invention is described herein in connection with the inscription of indicia on vehicle windows. The apparatus of the present invention, shown generally as 10, is illustrated in a simplified perspective view in FIG. 1 and in top plan view in FIG. 2. The apparatus 10 comprises an emitter housing 12 comprising a housing having top, bottom side and end walls. As illustrated, a marking head 14 is pivotally mounted on a side wall of the emitter housing. A laser source of conventional design that is capable of emitting a beam to which the surface being etched is not transparent and the associated electronics in support thereof are disposed in the emitter housing 12. The laser and associated electronics are connected to a suitable power source (not shown). An eximer or CO2 laser is preferred for use in the present invention because the emission of these lasers is particularly suited for etching oxide containing surfaces such as glass, anodized aluminum, ceramic oxides and the like. In particular, glass is not transparent to the CO2 beam so that the laser 18 is able to etch the glass surface. The emissions from other types of lasers will not etch glass because glass is transparent to

the emission beam of such lasers and the beam passes through the glass without etching the surface.

The marking head 14 may be mounted on the top, bottom or either of the side walls of the emitter housing.

In the embodiment illustrated in FIGS. 1, 2 and 3 a portion of one side wall adjacent the front wall of the emitter housing 12 defines a mounting face 18 that is biased forwardly inwardly with respect to the longitudinal axes of the emitter housing. Thus, the longitudinal axes of the emitter housing 12 and the marking head 14 are disposed at an angle to one another so that when the marking head is affixed to the mounting face 18 the emitter housing extends away from the marking head. In this manner the operator has full access to the control grip 20 and the emitter housing 12 does not interfere with the operation of the marking head 14. It will be clear, however, that it is not critical that the operator be behind the marking head 14 and all that is necessary is that the operator be positioned to reach the support handle 22 to position the marking head 14 and the control grip 20 to initiate firing of the laser.

A pivot joint, shown generally as 15, for pivotally mounting the marking head 14 to a wall of the emitter housing 12 is illustrated in FIG. 3. The joint 15 is formed by a cylindrical extension 16 from the side wall of the marking head 14 that is journaled in a corresponding opening 17 in the wall of the emitter housing 12 on which the marking head 14 is mounted. In the embodiment illustrated the pivot joint 15 is located at the mounting face 18. A suitable bearing assembly (not shown) of conventional design is located at the wall of the emitter housing to assist in supporting the cylindrical extension 16 and to provide easy pivoting of the marking head 14.

A through running passage 24 in the cylindrical extension is aligned with a corresponding passage 26 in the wall of the marking head 14 to define an optical path for the laser beam to traverse from the emitter housing 12 to the beam directing apparatus of the marking head. As is shown in FIG. 5, an adjustable alignment mirror 24 is disposed in the emitter housing 12 in the path of the laser beam to direct it through the optical path in the emitter housing 12, the pivot joint 15 and the

side wall of the marking head 14.

The marking head 14 comprises a housing having top, bottom and side walls. A front wall defines an emission face 16 and a rear wall 18. A pistol grip control 20 having a trigger 50 for initiating the laser etching and firing and a positioning button 52, the function of which will be explained below, is affixed to the rear wall 18,. A support handle 22 extends from the side of the marking head 14 opposite the side affixed to the emitter housing 12. The marking head 14 contains the beam control apparatus that comprises an X and a Y galvos mirror mechanism 32 and 34 respectively. The X galvos 32 includes a motor 36 and a rotatable mirror 38 that is carried by linkage 40 to the motor 36 for rotation about an axis normal to the emission beam as it is reflected from the alignment mirror 24 through the optical path. The Y galvos 34 similarly includes a rotatable mirror 38 connected by the linkage 40 to a motor 36 for rotation of the mirror 38 about an axis parallel to the emission beam as it is reflected from the alignment mirror 24. The Y galvos 34 also is in electronic communication with the printed circuitry 44 for positioning the mirror 38 in response to the control signals.

The mirror 38 of the X galvos 32 is disposed in the path of the emission beam of the laser as it is reflected through the optical path and reflects the emission beam to the mirror 38 of the Y galvos 34. The mirror 38 of the Y galvos 34 reflects the beam through the focusing lens 42 into the marking head 14. Rotation of the mirror 38 of the X galvos 32 causes the beam to be moved in an X direction on the surface being etched and the rotation of the mirror of the Y galvos 34 moves the beam in the Y direction. It should be clear that the position of the X galvos 32 and the Y galvos 34 can be reversed so that the emission beam contacts the mirror 38 of the Y galvos 34 first. To maintain the focal plane to keep the image in focus and to permit across the entire field of interest, it is highly preferred that the lens be a "theta" lens, that is a lens that provides a flat field and thus the image remains focused regardless of which portion of the lens the emission beam passes through. In the embodiment described herein, the focusing lens 39 is formed of a material transparent to the CO2 laser 18 beam. Germanium is one such material that can be used to with good results to form

the lens.

A printed circuit board 44 contains suitable circuitry and memory devices to receive and store control signals and to electronically communicate with the X galvos 32 and Y galvos 34 to relay control signals from a system controller for controlling the motors 36 to position the mirrors 38 responsive to the control signals. The control circuitry includes a suitable shift register and clock which operate in a manner well known in the art to receive the signal from the system controller and to transmit the signal to the appropriate operating components, i.e., the laser and the position sensors of the X galvos 40 and the Y galvos 42. The incoming signal may be in the form of timed pulses. The incoming signal thus contains the necessary commands to position the mirrors for scanning the beam over the surface being etched and to control the duration of the emission from the laser.

The front wall of the marking head 14 defines the emission face 16 that includes a port 60 through which the laser beam exits the marking head 14 and a pair of interlocks 62, each of which include a spring loaded pin to break the circuit to the laser and prevent the laser from firing unless the pins are fully retracted. A pair of suction cups 64 are carried on the emission face that communicate with a suction chamber 66 in the emission housing for drawing the emission face against the surface being etched. A vacuum line opens into the suction chamber 66 at 68 for reducing pressure in the suction chamber. As is most clearly shown in FIG. 7, the control signals are generated by a system controller 70, such as a conventional personal computer or equivalent device, such as a Motorola 68000 processor, to which data may be input manually by a conventional keyboard or by automated systems, such as barcode readers and the like. The system controller converts the data input to suitable digital control signal comprising an address code and command code for the operational components of the system. The command signals are output to the circuit board 44 for storage. The marking head 14 is positioned with the emission face 16 essentially contiguous to the surface to be etched. The suction cups 64 contact the surface and, due to suction from the suction chamber aid in drawing the emission face 16 against the surface to depress the interlocks and complete the circuit to the laser. An indicator light (not shown) on the top wall of the

marking head 14 flashes to indicate that the laser can be fired. Activation of the trigger 50 completes a circuit to the laser for firing and to the circuit board 44 for relaying the command signals to the laser to control the duration of emission and to the motors 36 of the X galvos 32 and Y galvos 34 for controllably scanning the laser emission beam over a surface being etched. In response to the control signal, the CO2 laser emits a high intensity light beam to which glass is opaque. The emission power of the CO2 laser preferably ranges between 20 watts and 25 watts. CO2 lasers in this power range produce a beam powerful enough to penetrate the glass surface for etching but not so deeply to weaken the structural integrity of the glass composition. Thus it is preferred that the CO2 laser have an output on the order of 20-25 watts to generate a beam of sufficient amplification to overcome interference due to condensation, dust, dirt and the like, which may collect on the reflecting mirrors and lens of the optical system. It will be understood, however, that laser beam emissions of greater or lesser wattage can be employed and controlled by speed of beam scannining to achieve etching and yet maintain the structural integrity of the glass.

For the purposes of description, operation of the system will be described in connection with the etching of a vehicle VIN number on the desired locations on the windshield and side window and automobile. The VIN number is input to the system controller via a keyboard or in the alternative via a bar code reader which is read a bar code which contains the desired data. The system controller converts the input data to a digitized control signal which comprises timed signal pulses for controlling the laser and the x and y galvos, 32 and 34 respectively, as described above. For marking VIN numbers on vehicles the marking head 14 and emitter housing 12 are carried by supporting apparatus of the general type described in U.S. patent 5,298,717. A frame including a track member for lateral movement and a swing arm support the emitter housing 12 and marking head 14. The weight of the emitter housing 12 and marking head 14 are counter balanced by a weight and a motor powers movement along the track member. The motor is operated by depressing the positioning button 52.

The emission housing 12 and marking head 14 assembly is moved to a position adjacent the surface to be etched. The marking head 14 is pivoted as necessary to insure that the emission face

16 is in essentially the same plane as the surface to be etched. The emission face 16 of the marking head 27 is placed adjacent the surface to be etched so that the pins of the interlocks 62 are in contact with the surface to be etched. The emission face 16 is drawn into contiguity with the surface being etched by the suction cups 64 and the pins of the interlocks 62 are retracted to complete all circuits to permit operation of the CO2 laser and to insure that the marking head does not move during the etching process.

In addition, retraction of the pins of the interlocks 62 close the circuit from the circuit board 44 to relay the control signals to activate the galvos motors 36 to locate the reflecting mirrors 38 of the X and Y galvos, 32 and 34, in the proper plane to cause the beam to be scanned across the surface to be etched in the desired pattern to etch the VIN number in the glass. When the pattern has been completed the control signal turns the CO2 laser 18 off and the emitter housing 12 and marking head 14 assembly can be moved for the next etching operation.

From the foregoing it will be seen that the apparatus of the present invention provides a quick, safe, and environmentally acceptable method for etching glass which lends itself to automated production operations. The power of the CO2 laser 18 can be readily controlled to avoid any structural damage to the surface being etched and the process is relatively fast, on the order of a few seconds compared to minutes with the chemical sandblasting techniques.

As will be understood by those skilled in the art, various arrangements other than those described in detail in the specification will occur to those persons skilled in the art, which arrangements lie within the spirit and scope of the invention. It is therefore to be understood that the invention is to be limited only by the claims appended hereto.

Having described the invention, I claim: